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THE PSYCHOLOGICAL BULLETIN

GENERAL REVIEWS AND SUMMARIES

TROPISMS AND INSTINCTIVE ACTIVITIES

BY WALLACE CRAIG
University of Maine

Comprehensive Studies.—Jones's book (14) is a popular, interesting account of the ancestors of man, who became arboreal probably early in the mammalian age, and of the influence of arboreal life upon every part of the organism, especially the nervous system.

Szymanski's long paper (42) consists of twelve distinct articles, grouped in three parts. 'I. Beobachtungen und Versuche über Angeborene Handlungen." (1) The worm *Tubifex* (pp. 2–33). If all animals be divided into the optical, the osmatic and the tactile, this worm is an extreme example of the tactile: living with its head buried in its nutriment (mud), it has little use for distance-receptors. (2) In an insect larva (*Arge*, a saw-fly), arousal of the fear reaction, even amputation of a leg, has no effect upon the rate of heart-beat (pp. 33–37). (3) "Ueber Abwehrreflexe bei Raupen" (pp. 37–48). This is a study of the phylogeny of a reflex. It is traced back to "Probierbewegungen." Perhaps all reflexes, like voluntary acts, are secondary phenomena, having evolved by selection from varied movements (Jennings) which constitute the *Grundlage* of all behavior. (4) "Ueber Putzreflexe bei Insekten" (pp. 49–86). Each species of insect cleans especially that sense organ, whether eye, antenna, or mouth-part, which is most used by it. Insects make movements to clean the sense organs while awaking from a state of etherization; thus the deficiency of excitation caused by the action of ether on the nervous system is projected outward, by the law of "excentric localization" as if it came from

the sense organs. (5, 6, 7) (*v.i.*, under *Cycles.*) "II. Versuche über die Entstehung der rezeptorisch-motorischen Gewohnheiten." (1) (Pp. 127–157) Dogs failed to distinguish between a plain black wall and a black wall with a white pyramid drawn on it. (2) (Pp. 157–197) A study of the disappearance of habits. (3) (Pp. 197–220) A series of tests of rats learning a maze, leading to the conclusion that the reduction of errors to zero is not due to mere repetition but requires a "vital interest" such as hunger. "III. Allgemeine Betrachtungen über das Verhalten der Tiere. (1) Körperstellungen als Ausdruck innerer Zustände der Tiere" (pp. 220–237). The principal attitudes are sleep, rest and readiness, the last showing a few principal varieties. All can be grasped under the concept of attention. Attention must be given a biological definition. It is a setting of the organism for the reception of certain stimuli. Sleep is negative attention. In the sleeping attitude, each form protects its most important sense organ; *e.g.*, insects protect the antenna. (2) "Der Umfang der rezeptorischen und Aktionssphäre" (pp. 237–244). The author states (but the reviewer does not agree) that in most animals, perhaps in all, even including man, the "action sphere" is restricted to actions that are inborn, hence is narrowly limited, whereas the "receptory sphere" is comparatively unlimited.

Wheeler (**49**), from a survey of parasitism in wasps, bees and ants, concludes that in this group a parasitic species evolves from the host species itself. Some indiviudals within a species take to robbing others of the food destined for the larvæ. The parasitic habit thus started continues, by a "circular process." The parasite becomes a distinct species. In time, it exterminates its host. It gradually transfers its attentions to a new but related host.

Tropisms, Taxes.—Crozier and Arey (**8**) find that *Onchidium* in the laboratory is always photonegative. Yet in nature it is diurnal. Its heliotropism is, the authors think, of no use, and is, in the natural habitat, centrally inhibited by other stimulations. Piéron (**28**) finds that limpets, in homing, when on rough rocks, are guided mostly by the relief of the rock surface (tactile), less by the inclination toward the vertical (weight), least by the direction of light rays. On smooth rocks they rely on the last two factors. It is interesting to compare these two studies, on *Onchidium* and on the limpet.

Grave (**10**) finds that in the ascidian which he studied the free-swimming period is of short duration—ten minutes to two

hours. The larvæ are positively heliotropic for a brief interval at first. Becoming negatively heliotropic and probably positively geotropic, they descend and become attached.

Rabaud (29) finds that a myriapod (*Schizophyllum*) moves from lighted places into dark; but does this neither by a tropism nor by differential sensibility. It is phototactic, but not phototropic. It is "stenophote," living in the dark; whereas animals that flourish in the light are "euryphote."

Riley (31) studied the problem, What becomes of apterous water-striders if their pool of water dries up? Some of them, traveling overland, succeed in reaching other pools, but many die. Weese (48) finds that the horned lizard reacts more definitely to a gradient of soil temperature than to one of air temperature.

Small (36) finds that in a plant, *Vicia Faba*, geotropism of the root-tips obeys Weber's law, and does not require statoliths but is due to differential increase in the permeability of the protoplasm to ions, which is detected by increase in electrical conductivity. This change in the protoplasm resembles that in a contracting muscle.

Righting Reactions.—Szymanski (44) observed how beetles, when turned on their backs, regained the normal position. In sixty species he found twelve different methods. But in each beetle there are several variations of the method of turning over; they are tried in turn until one of them produces the end-effect.

Locomotion.—Copeland (5) gives convincing evidence that the locomotion of the mud snail *Alectrion* is due to ciliary movement. Stimulation of the tentacles induces movements of the pedal cilia, showing that the latter are, directly or indirectly, under control of the nervous system. Crozier (7) adds a new type of locomotion to those known among gastropods: in *Xenophora* the foot is advanced, is attached by suction, then draws the shell forward.

Müller (25) has made an extended study of a crustacean resembling *Branchipus*. The rate of movement of the swimming feet varies directly with temperature and light, and inversely as the viscosity of the medium; it decreases with age.

Stellwaag (39) studied the means by which insects steer during flight. Some investigators had claimed that they steer by shifting the center of gravity; as, by moving the abdomen. The author took shadow photographs of flying insects, and found that the abdomen does not move. He studied the wing movements, and saw that the two wings, though always synchronous, may move in different planes and with different amplitude.

Szymanski (47) points out that every rain which falls on a meadow isolates many insects on tiny "islands." Various insects escape from these islands by flying, jumping, swimming, running on the surface film, crawling under water. The swimming movements of ants are complex and highly adaptive.

Grave (10) finds that Ascidian behavior is not so similar to that of vertebrates as has been assumed. The free-swimming larva swims with constant rotation on its long axis.

By an examination of the mechanism of flying-fishes, Ahlborn (1) shows that they cannot fly, except by momentum.

Migration.—Baldwin (3) has inaugurated a new era in bird-banding by systematically trapping the birds. He has discovered that individuals winter in successive years in the same winter quarters; that yearlings return to the locality where they were hatched; that a pair of wrens, after rearing one brood, became "divorced," each finding a new mate and rearing a new brood.

The title of Bretscher's paper (4) may be misleading. His thesis is that bird migration occurs when the time has come, regardless of weather. He seems successful in proving that migration is independent of temperature as such. But Smith (37) finds that migration records (of all species massed together) show high correlation with barometric conditions and favorable winds

Cycles.—Syzmanski continues his studies of the daily cycle: in earthworm, snail, crayfish, blow-fly, rabbit, cat, dog (46); in tree-frog, ringed snake, jackdaw (42, sections I, 5, 6 and 7); in white rat, dancing mouse (43); in the human infant (45). The ringed snake showed activity regularly at midday, which must have been due to inner factors, for it was not due to hunger nor temperature. Adult man is an "optical" animal, and as such is "monophasic," with one period of activity and one of rest in the nychthemeron. But the human infant, 1 to 10 days old, is "polyphasic," with 5 or 6 periods of activity; it is a "tactile," resembling the earthworm.

Rhythm.—Snyder and Snyder (38) have solved, at least in great part, the problem of the synchronous flashing of fireflies. Observing for several seasons, they saw on a few occasions that the fireflies did flash synchronously. They found that the rate of flashing increases as the temperature rises. At a given temperature the rates of many individuals are nearly identical. This gives a basis for synchronism. "On the other hand, as far as the individual beetle is concerned, the synchronous flashing would be purely accidental and utterly devoid of any relation to a higher

intelligence or to instinct or any community activity." These findings are similar to those of Shull on the synchronous chirping of crickets.

Swindle (41) tells us that he has "many pounds of kymograph records," and he gives a few samples, but he does not tell precisely what data these represent. He states that a cockatoo can be trained to beat simultaneously in four different rhythms, with 5 to 11 beats in the measure. This remarkable feat will excite the envy of our rag-time pianists and our jazz dancers.

Defense.—Crozier and Arey (9) find that the snail *Onchidium floridanum* exhibits two types of coloration which the authors think inexplicable either as concealing or as warning colors. This species has repugnatorial glands which, when the animal is touched, shoot their irritating contents with some accuracy toward the stimulating object.

Cowles (6) observed that hermit crabs, on changing to a larger shell, seized the sea-anemones which were on the old shell and transferred them to the new one.

Pantel and Sinéty (27) studied behavioristically the whole subject of pigmentation change in phasmids. Many facts in the rearing of the young favor the theory of color adaptation: the color harmonizes with that of the substratum, even when the substratum does not supply the nourishment. Adaptation is effected partly by the insect traveling to the substratum of its choice.

Siedlecki (35) reports field observations on the "terrifying" attitude.

Immobility.—Rabaud (30) finds that "death feigning" is only a special case of a reflex immobility which is found in some degree in all arthropods. The arousal from immobility is due to an antagonistic reflex. Both the immobilizing and the mobilizing stimuli are tactual. The chief zones of the former are on the cephalothorax. The chief zones of the latter are the soles of the tarsi and the tip of the abdomen. Thus an insect holding firmly to the substratum, with tip of abdomen touching the substratum, resists immobilization. The entire integument is replete with sense organs connected with motor-excitatory and -inhibitory centers, the latter being more at the anterior end, the former at the posterior. Reflex immobility is only an exaggeration of the normal functioning of these paths, an exaggeration of muscular tonus. Reflex immobility resembles sleep, differing chiefly in the greater muscular tension.

Szymanski (44) finds that in beetles the "hypnotized" con-

dition differs from death feigning in that the former is passively, the latter actively assumed. Death feigning in its highest development is accompanied by structural modifications, the insect drawing its legs, tortoise-like, into recesses in the trunk.

Fear.—Griffith (**11**) observed that white rats, on seeing, hearing and smelling a cat for the first time, showed extreme fear. This fear might have been due to the feline odor specifically, or merely to its unfamiliarity. Kunkel (**20**) observed that his white rats showed fear on first perceiving the odor of a cat, but not on first perceiving the odor of a rabbit, from which he concludes that the fear is aroused by the feline odor specifically.

Physiology.—Moore (**23**) finds that castrated rats with implanted ovary show typical maternal behavior; spayed females with implanted testis show typical male behavior.

Oltramare (**26**) reports that rabbits, guineapigs, cocks, pigeons, tortoises, frogs, tritons and fish have been kept in a dark room, some of them more than three months, with no profound effect on their vital condition. They show decrease of waste products and of muscular activity, and increase of stored nourishment, these physiological conditions being due to a reflex from the retina. Pantel and Sinéty (**27**) report that phasmid larvae which were experimentally blinded, by a non-traumatic method, showed an unfavorable physiological effect, indicated by change in the number of molts and in the rate of transformation.

Neurology.—Arey and Crozier (**2**), from a study of the behavior of *Chromodoris*, conclude that the gill crown and some other parts are controlled by a "nerve net."

Moral (**24**) finds that the effect of some anesthetics is greater at high temperature. This may be due to differential solubility: at high temperature these drugs are relatively more soluble in lipoids, hence pass into the nerves; at low temperature they are relatively more soluble in water, hence pass out of the nerves. Certain other anesthetics show the reverse phenomena.

Komine (**18, 19**) is using non-protein nitrogen in the brain as a measure of catabolism.

Riddle has a strain of ataxic pigeons descended from a female that was reproductively overworked. Hoshino (**13**) finds that the brain in these birds anatomically resembles that in hereditary ataxia in man. Koch and Riddle (**16, 17**) find that the ataxic brains are chemically underdeveloped. They have made out (**17**) an "age series" of normal pigeon brains, showing that chemical

differentiation follows the same course in the pigeon as in the rat and man.

Kuntz (**21**) finds that the sympathetic nerve fibers in the ovary and in the testis of the dog supply no cells nor tissues except the muscle fibers. Rogers (**33, 34**) shows that in the pigeon removal of the thalamus destroys the temperature-regulating mechanism. Wintrebert (**50**) observed that *Scyllium* commences automatic rhythmic movements at an early embryonic stage. These are independent of the nervous system. Control of muscle by nerve is established gradually.

Meltzer and Githens (**22**) were able to abolish "voluntary movements and the sensation of pain, without affecting reflexes" in dogs by a blow on the cranium. In such animals, nose-licking persists, indicating that it is a reflex. It may be induced by compression of the nasal septum, but the licking occurs only when the compression has ceased. Apparently the compression stimulates simultaneously two antagonistic sets of fibers, exciting and inhibiting, the former having an efficient after-effect.

Philosophy.—Hooker (**12**) presents the idea that organisms exhibit two fundamental processes: behavior and assimilation. In behaving, they react according to the theorem of Le Chatelier. In assimilating, they perpetuate themselves by autocatalysis. Kappers (**15**) points out interesting analogies and relations between the phenomena of growth and nervous and conscious action.

Sumner (**40**) shows reason to believe that the principle of trial and error can be given a still wider application than it has had. It will help us to explain the most difficult cases of adaptation and "organic purposefulness," including those of regeneration. "We may suppose the organism to be in a condition of 'unrest' until the end is achieved." Even the Lamarckian principle involves selection, because "modifications produced by the environment are in the nature of reactions to stimuli," and all reactions are selective.

Ritter (**32**) emphasizes the unity and continuity of the living organism. We should study the organism as a whole, not only in parts; in nature, not only in the laboratory. Both analysis and synthesis are needed. He emphasizes also individuality and specificity. He gives (vol. **2** pp. 246–274) a number of interesting descriptions of instinctive behavior.

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SENSORY PHYSIOLOGY OF ANIMALS

BY K. S. LASHLEY
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The literature for the year indicates some revival of interest in animal behavior after two years of short commons. As usual the bulk of material deals with photic sensitivity, but it is marked by a tendency to turn from type studies of tropisms to an analysis of pattern vision in invertebrates. Labyrinthine function occupies second place in number of studies, perhaps as a result of the general interest in problems of aviation.

In the bibliography a few papers which have not been available to the reviewer are included in order to bring the references up to date. These are marked by an asterisk.

General Studies.—Szymanski (**60**) distinguishes between dynamogenic (antreibenden) and effective stimuli in relation to animal learning. The former, as hunger, increase excitability; the latter direct the organism's reactions. The rate of learning varies with the character of the dynamogenic stimulus. Buddenbrock (**8**) also emphasizes the dynamogenic effect of sensory stimulation in a study of the function of the "balancers" of diptera. He tested the function of these organs in a variety of ways. Their importance varies in different species but, in general, their removal results in a reduction in speed and especially in the amplitude of the movements of the wings. Consequently flies deprived of balancers are either unable to rise or to continue flight; although they may steer and balance in a normal manner for short distances. In some species removal of both legs and balancers inhibits movements of the wings although insects with either legs or balancers can fly in a normal manner. Hence the author concludes that the vibrations of the balancers serve solely to excite afferent impulses which reinforce the innervation of the wings.

Arey and Crozier (**2**) give an extensive account of the natural history and sensory reactions of *Chiton*. The molluscs are sensitive

to contact, light, and chemicals and probably have separate receptors for these. Sensitivity to temperature is not established. They report a similar study of the nudibranch, *Chromodoris* (14). There is evidence that the nervous system of this mollusc consists of a peripheral nerve net and a central synaptic reflex system. Both papers contain too many details for adequate review here.

Sensitivity to Chemicals.—Shelford (57) found that fishes reacted positively to dilute solutions of various narcotics and would remain in them until death occurred.

By various training methods Frisch (22) determined the differential sensitivity of the bee to a number of odors. The insects are able to distinguish some odors which are indistinguishable for man, but in general there is a greater similarity in sensitivity than the great difference in sense organs would lead us to expect. The threshold of the bee is not lower than that of man. The paper is certainly the most important that has appeared on olfacton in invertebrates.

Schut (56) tested the reactions of a snail to a number of 'artificial' and 'natural' odors. The snails were negative to some and positive to other odors of all classes irrespective of the intensity of the odors for man.

Henning (29) considers the question raised by Binet and Passy as to whether the dog is able to smell plant odors. He trained the animals to select an odorous cloth from among a series or to avoid a room permeated by a given odor. Untrained animals gave no detectable reaction to odors without biological significance but they could be trained to react to any type of odor that is detectable by man. Reaction to cues other than odor does not seem to have been ruled out.

Static and Auditory Sensitivity.—Jordan (36) denies the sensory function of Reissner's fiber in fishes, giving embryological and experimental evidence that it does not control the curvature of the body. Ruth (54) suggests that an increased secretion of the calcium glands which are normally concerned with the formation of otoliths in the lizard may result in increased activity during pregnancy, at which time the secretion is increased. Moore (47) describes the righting reaction in the starfish as due to a series of direct reflexes called out by stimulation of the arms and tube-feet.

Tracy's paper (61) on the anatomy of the labyrinth and its connection with the swimbladder in fishes contains suggestive speculations concerning the function of the latter. Maxwell

(42, 43) finds that the utriculus of the dogfish is capable of mediating all of the animal's reactions to gravity if the semicircular canals and sacculus are destroyed. Similarly, the semicircular canals show both static and dynamic function when the vestibule is destroyed.

Muller (49) describes the behavior of guinea pigs after unilateral and bilateral destruction of the labyrinth and cerebellum in various combinations. Destruction of labyrinth and cerebellum on the same side reduces the symptoms of destruction of either alone, on opposite sides it exaggerates the symptoms. From experiments on amphibia, reptiles, birds, and mammals, Ivy (35) concludes that the quick component of labyrinthine nystagmus is a subcortical reflex over which the cerebrum has an inhibitory influence. Prince (50) finds that in cats the symptoms following labyrinthine destruction disappear after 48 hours. Decerebration then results in a renewal of the symptoms.

Reed (51) compares the condition of the columella and operculum in different salamanders.

By trapping all frogs coming to a pond for breeding and keeping records of croaking at the pond Cummins (15) found that there is no relation between periods of loud croaking and migration to the pond. The croaking does not attract migrating frogs.

Hunter (34) reports a variety of experiments supporting his earlier view that the white rat is insensitive to periodic sounds although it reacts readily to noises.

Sensitivity to Light.—Hecht has contributed four papers bearing upon his theory of the chemical nature of photic stimulation. In brief, the theory assumes that the photic response may be divided into two phases. A certain length of exposure is necessary to produce a reaction (sensitization period). After exposure to light a varying interval preceeds the reaction, which may occur after cessation of the photic stimulus (latent period). The sensitization process is shown to be a simple photochemical reaction (28) since it is very rapid, is little affected by temperature, and follows the Bunson-Roscoe law for exposure time and intensity. For the clam, *Mya*, 5.62 meter candle seconds are required to produce a reaction. The theory assumes that the sensitization process involves the breaking down of a photosensitive substance into two "precursors." under the action of light. These recombine spontaneously in darkness. When *Mya* is kept in darkness its reaction time to light is reduced and the rate of reduction follows the law of a bimolecular reaction. At each stage in adaptation to light a

balance is reached between the amount of precursors and of photochemical substance (25). The precursors act upon a second substance to excite a response, and the latent time is due to the slowness of this process. Below 21 degrees the latent time is affected by temperature as a simple chemical reaction (27). The length of the latent time is a linear function of the exposure time and this, with other evidence, makes it probable that the precursors catalyze the reaction of the second substance (26).

Snyder and Snyder (58) find that the rate of flashing in fireflies, when freed from chance inhibiting agents, varies with the temperature.

Laurens and Hooker (39, 40) determined the relative stimulating value of spectral lights for Volvox by the minimum exposure time necessary to initiate orientation. They used lights of known intensity and equated each spectral light with a standard white light. This gave the region of greatest stimulating value at $\lambda = 494\,\mu\mu$. They then compared the rate of movement in spectral lights of equal energy. The greatest rate appeared also at $\lambda = 494\,\mu\mu$.

Crozier (11, 12) found that shading normally induces contraction of the gills in *Chromodoris* but high temperature, direct sunlight or low alkalinity of the sea water inhibit the response. The movement of the gills seems primarily controlled by the necessity for eliminating carbon dioxide. Crozier and Arey (13) report that although the mollusc, *Onchidium*, is definitely negative to light under laboratory conditions, in the vicinity of its "nest" it is undirected by light. Removed from the nest environment, it becomes heliotropic. The phototropic response has no adaptive value.

Schut (55) finds that land snails (*Helix aspersa*) are negative to direct sunlight, probably on account of the heat rays. They do not give any reaction to shading. In diffuse light the snails see and avoid small objects 2 mm. from the eye-bearing tentacles. Franz (20) studied *Helix variabilis*, which is positive to light. In diffuse daylight the eyes play little if any part in directing movement. Buddenbrock's "Lichtkompassbewegungen" (*v.i.*) could not be observed. Buddenbrock (6, 9) reports extensive studies of the reactions of a land snail to light. With strong contrasts of illumination the eyes control the tonus of the body muscles producing typical tropisms. When the environment does not contain strong contrasts the animals tend to maintain a constant orientation toward some object, irrespective of whether it is brighter or darker than the background (Lichtkompassbewegungen). They avoid

obstacles at a distance of more than 10 cm. irrespective of their luminosity.

Demoll (17) refutes Hess's theory of the mechanism of accommodation of the eye of *Alciopids* and ascribes it to the action of muscles controlling movements of the lens.

Blees (4) confined *Daphnias* in glass tubes so that they must move away from light in order to escape from the tubes. These crustacea are strongly positive to light, but after practice they showed improvement in ability to escape from the tubes against the attraction of the light. Hess (32) tested the differential sensitivity to wave length of ten different species of *Cladocera*. A variety of methods was used to test the relative stimulating effects of monochromatic light, the principle of most being the opposition of the monchromatic band to white light from a standard source and regulation of the intensity of the latter until the animals just orient to the monochromatic band. The relative stimulating effects were found to correspond to those for a totally colorblind man.

Lodge (41) reports that flies have no color preference and are attracted to baits by odor. Riedel (53), measuring the photoelectrical changes in the eye of the lobster, found a continued positive deviation in the light adapted eye, a steep positive initial deviation with quick falling off, in the dark adapted eye. The form of the curve varies with the temperature. Cajal (10) describes the structure and nervous connections of the ocelli of various insects.

Minnich (45) made many tests of orientation in the bee and gives evidence in support of the continuous action theory of photic stimulation. Active bees are always strongly positive to light (46) and swarming is due, not to an increase in phototropism but to a general increase in activity.

The Hess-Frisch controversy concerning color-vision of bees is continued with increased asperity in polemics by these investigators (30, 21). Each reviews his own methods and results, maintains that they form an adequate test of color-vision, and accuses the other of bad technique and worse logic. The controversy seems likely to continue until someone steps in and settles the question by the use of really scientific methods.

Hess (33) describes experiments on orientation to light in caterpillars from which he concludes that their reactions are not tropisms. The spectral region of maximum stimulating value for them is in the yellow-green to green: hence they are not like plants in their responses to light and resemble a totally color-blind man.

They are extremely sensitive to ultraviolet rays and this leads the author to extensive speculations on the function of compound eyes in reception of ultraviolet light.

Eltringham (**19**) finds that the visual field is reproduced accurately as a mosaic in the compound eye of butterflies, with good definition at distances of 3 cm. to 1 meter. He holds that butterflies distinguish colors.

Dolley (**18**) tested the relative stimulating effects of continuous and intermittent light of flash frequencies from 2 to 100 per second, as measured by the orientation of *Vanessa*. At flash frequencies of 5 or less per second the intermittent light is less effective than continuous. Between 20 and 30 per second it is more effective. At other rates its effects are equal to those of continuous light. The stimulating effect varies also with the ratio between the periods of light and darkness and this in turn varies with the flash-frequency. The reactions of the insects depend somewhat upon past experience, previous violent mechanical stimulation sometimes making them turn toward the weaker instead of the stronger of two lights.

Grave (**23**) describes the structure and behavior of the larva of an ascidian. When the tadpoles are first released from the parent colony they are strongly positive to light. They later become indifferent. They are at first negative to gravity but later seek the bottom. The method of attachment is described.

Hess (**31**) concludes from the facts that fish react promptly to food dropped on the water directly above them and that schools of minnows show flight reactions at movements in the air above them that the eye of the fish has a visual angle of about 180 degrees. He attempts to prove this by the construction of a rough model of the fish eye and by an analysis of the relation of the spherical lens to the retina and iris. The silvery sheen on the sides of many fish has value as protective coloration, since it increases the light reflected from the sides and makes the fish appear brighter when seen against the sky and darker when seen against the bottom. Under conditions not described he finds that in the water the light coming from above is more than nine times brighter than that coming from below. He describes a slight modification of his earlier method of studying color-vision and concludes, as usual from studies with this method, that fishes are totally color blind.

Reeves (**52**), with more accurate methods, finds that fish are sensitive to wave-length irrespective of intensity. Dace and sunfishes failed to learn to discriminate between white lights of greatly

different brightness, or learned only with great difficulty. An attempt was made to determine the relative stimulating value of colored lights for the fish. They were then trained to discriminate colored lights (filters) and the association persisted during large variations in the intensity of the lights. The paper embodies the most careful work yet done by training methods upon color-vision of fishes. The tests on the brightness values of the colored lights for the fishes are not altogether convincing, however, and this of course is the crucial point in such studies.

Delage (**16**) points out that the supernumerary fovea in raptores may serve to determine the point from which the bird begins its swoop upon its prey, provided that the height of flight is regulated according to the speed. Bard's paper (**3**) contains some speculations on the function of pigments in the retinae of various animals, without experimental tests.

Meadows (**44**) reports that horses in the tropics suffer from night blindness as a result of sunlight glare. Hartridge (**24**) discusses the function of various forms of pupils. The vertical slit of the cat gives great illumination with little aberation for vertical contours, corresponding to the tree-dwelling habits of the felidæ. The horizontal pupil of the sheep sacrifices vertical for the sake of horizontal definition.

Szymanski (**59**) attempted to find out whether dogs could recognize pictures of objects, but he could not train the animals to distinguish any patterns, although they learned to distinguish between illuminated and dark passages.

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HABIT FORMATION AND HIGHER MENTAL CAPACITIES IN ANIMALS

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Last year we had two studies of transfer of training. This year there is a third from the same laboratory by Wiltbank (21). Like the work of Webb, it is concerned with maze learning, in fact uses similar mazes, though these are differently related to each other, and the two monographs should be studied together. Five mazes were learned, designated in order from *A* to *E*. One group of rats learned *A*, then *B*, etc., to *E*; a second group learned *B-C-D-E-A*; and so on to a fifth group, which learned *E-A-B-C-D*. A sixth group learned *E* and then *D*. Tabulating results on the basis of number of trials, total errors and total time, a greater or less positive transfer was found in all cases from the first learned to the second learned maze. In two cases the second learned maze had a section (quarter) identical with the corresponding section of the first. These cases showed the greatest positive transfers, but this was not due simply to greater savings in the identical parts, other parts showing still greater savings. Stating transfer in terms of percentages of savings, there were some indications that these were greater when transfer was from the more difficult to the less difficult maze rather than from the less to the more difficult; but the results were not consistent. Corresponding to this, with regard to the mazes *D* and *E*, he finds that, on the whole, there is an advantage in the total effort involved in learning both, if the harder maze is learned before the easier rather than the easier before the harder; the absolute amount saved is greater in the former case. All this seems to the reviewer extremely doubtful in view of ter-

fering factors, such as the peculiarity of the *D* maze. If we tabulate Webb's results to show the absolute amount saved with each pair of mazes in both orders of difficulty, and the total effort involved in learning each pair in both orders of difficulty, we find a decided tendency in favor of the order less difficult—more difficult. This corresponds with the point noted last year, that differences of the second mazes are more important for absolute saving than differences of the first.

In tracing the effects through a series of mazes learned, the transfer in any given case was found not to be a function of the adjacent mazes only, but of all preceding mazes learned. On the whole, the transfer effect is cumulative, tending to increase with the number of preceding mazes, but not invariably. Each group of animals relearned its first maze after the four other mazes had been mastered. Only one group showed definite evidence of retention of the specific habit.

Maze *E* was given two, four, eight or sixteen trials with different groups of rats, then *D* was learned, then *E* was mastered. Other groups went through similar experiments with the functions of the two mazes interchanged. Two, four or eight trials in one gave negative effects in the other measured in trials and errors, positive effects measured in time. Sixteen trials gave positive transfer. Considering the maze which was given the limited trials, and then, after the second maze, was finally mastered, we find in general a reduction of effort in learning (except in the case of sixteen preliminary trials) compared with the control group which learned without the interruption of the second maze; and especially was there a saving in errors and time in the trials following the second maze compared with the corresponding period in the learning of the control group. In several cases the performance in the trials immediately after the interruption was better than in those before—they had contined to learn the first maze while learning the second.

As the main factor contributing to negative transfer, Wiltbank gives kinaesthetic habits driving the animals into blind alleys; as factors giving positive transfer, he names overcoming the instinct of timidity, association of getting food with the maze situation, and "practise in error-elimination with its attendant resistance to the blind alleys once frequently entered" which "cannot but leave its impress upon the reactions of the organism in any similar situation."

In a second article (22) Wiltbank criticizes Peterson's "Com-

pleteness of response" theory, which he interprets as the sum-total of responses occurring in the maze which are present already in tendency when the animal enters the maze. A first objection which he raises is that Peterson would make the tendency to respond to the true path the force which draws the animal out of the blind and impels him along the true path, that this force might not be as strong when the animal leaves the blind as on entrance, and that the importance of the stimulus of the blind end is not recognized; all of which seems to the reviewer a misunderstanding of Peterson, at least in part. Other difficulties are to understand how the erroneous tendency is directed into the successful tendency when the animal leaves the blind and how the successful tendency is thereby strengthened, points which surely need more definite treatment from Peterson. Wiltbank refers to the experimental result above, that an animal may continue to learn a maze partially learned while learning another, and says this could not be if the rat in the second maze were developing "a set of tendencies constituting a complete response." He suggests that in running the maze the stimuli are serial, but before one has ceased, the next may become effective. Consequently in a blind, the association may, as it were, run ahead of the animal's legs, and lead him to turn before the end, while in a section of the true path, he cannot turn into the next section before he reaches it. He calls this the principle of "completeness of the single successful movement," with incompleteness of the unsuccessful.

Brockbank (3) used the Watson circular maze with camera lucida attachment to study retention of habit by the rat. Some groups of animals ran one trial per day, others ran three trials in immediate succession each day. Retention was tested in some cases after seventy days, in other cases after forty-five days, in still other cases after thirty days from completion of learning. The rats were given exercise equivalent to the maze running during the retention interval. It was found that persistent errors or points where establishment of the habit was difficult during the learning period, but which had finally disappeared, tended to reappear in the retention tests. Distances traveled in different alleys during learning had no relation to distances traveled in redintegration. The number of errors and the total trials made during learning was far greater with the three-trials-per-day groups than with the one-trial-per-day groups. The difference between the two methods was relatively small in the redintegration tests except in the time

required. One may suggest that it would add to the value at this point if some groups were run in which one trial per day only were used in the retention tests both for those which had used one-trial-per-day in learning and those which had used three-trials-per-day in learning. Learning a rope-ladder problem during the retention interval did not interfere with accuracy in redintegration. In general when one animal had better established the maze habit than another animal in a given learning period, the same animal showed the better results after the retention interval. Practise in learning other problems (inclined plane box, etc.) previous to the maze facilitated learning and consequent retention of the maze.

Dashiell (9) is concerned with the question whether, in learning two different habits which are similar in kind it is better to learn one completely and then learn the other completely, or to practise them alternately. He used rats learning two arrangements of the maze; children learning a maze (made of screens) in a forward direction and in the reverse direction; adults learning two pencil mazes, two card sorting habits with different sets of cards, and two methods of adding. In all cases, learning by the complete method was more economical than learning by the alternate method. Especially was the irregularity much greater with the alternate method. The number of trials was not clearly different in the case of the rats.

Two papers are concerned with the value of distribution of practise in maze learning. In Carr's experiments (6), adults learned the pencil maze. One group used distributed trials in the first part of the learning period, concentrated in the last part; the second group used the reverse arrangement. The results indicate that the extra value of distribution is mainly in the first part of the learning process. This is at least consistent with Lashley's results (14). Lashley used rats in a simple maze offering a single choice between a blind and an alley leading to the food. A first group of animals learned in the ordinary way. The variation with the second group was that they were allowed to explore the maze without food for twenty minutes the day before training began. A third group was not allowed to correct errors, but was returned to the starting point at once if they entered the blind. With a fourth group a dish of food covered with netting was placed in the blind, otherwise as the first group. One part of each group learned with two trials per day; a second part with ten trials per day. Differences between the groups were small with two trials per day; but ten trials per day were much less effective with all groups, and

also showed large differences between groups, especially the fourth group was much less efficient and the second distinctly more so than the first. The results indicate that the low value of concentrated practise is due to cumulative effects in the later trials of the exploratory instinct, and of such emotional excitement as that from being picked up in the food box, together with a greater tendency to repeat temporary errors, rather than any process of neurological fixation.

Carr (5) continues his work on the alternation problem. His apparatus is different from that formerly used. A four inch runway follows the sides of a large rectangle and a cross runway connects the middle of the two shorter sides of the rectangle. The food box, which is also a starting box, is placed near one end of this cross runway. The animal (rat) started from this box through the longer part of the cross runway and through the right or left side of the rectangle (either of which could be blocked) to the food. This arrangement prevented any distinctive orientations in the food box following the different trials. The habit of simple alternation was learned more or less well though more slowly than formerly, and the control of each choice was shown to be due to the stimuli from the preceding run. The association was formed when there was as much as thirty-five seconds of time between trials, consequently between stimuli and response; in fact, up to this limit at least, success had no definite relation to time interval. Carr decides that the connection between retained effects of stimuli from the preceding activity on the one hand and the response on the other hand was formed directly, without any survival that could be called memory bridging the interval.

Carr and Koch (8) used the same apparatus in a further variation of the alternation experiment. Two groups of animals were used. The first group learned the habit as usual. With the second group a door at the end of the cross runway blocked the entrance into one of the return alleys (alternately the right and left), so that free choice was impossible, there could be no errors. Eighty per cent. of the trials were done under this objective control; twenty per cent. consisted of series of free-choice tests interpolated at regular intervals to measure the acquired association. The results indicated that the controlled runs were of some value, but that they were less effective than those with free choice. Even with the motor impulse of active participation in the reaction, a controlled response is of low value. Fixation of a connection seems to be a combined process of selection and rejection.

The relation of time interval to the formation of associative connections is further studied by Carr and Freeman (7). A modified alternation apparatus was used. The return alleys were widened and were broken by partitions extending half-way across the alley alternately from its two sides. Electric buzzers were placed in each return alley. At the beginning of each trial both doors from return alleys to food box were closed. The rat was placed in the center path and entered one of the return alleys. In part of the cases the corresponding door was opened at once and the rat reached the food. In these cases the buzzers were not sounded. In the other cases the opposite door only was opened and the rat was compelled to turn at the closed door and go back and through the other alley to food. In these cases the buzzers were sounded. With one group the sound was made as the animal was turning at the closed door; with a second group it was made about one second before the closed door was reached; with a third group it was made about the same interval after the rat turned and started back. Formation of an association between the sound and turning was tested at regular intervals by giving the sound at various times before the door was reached and success was shown by the animal turning at once in response to the sound. Practically no connection was established in the third group, it was formed with fair rapidity in the first, and most rapidly in the second.

Hunter raises a very important question in connection with a modified alternation experiment (11). Two pieces of apparatus were required. The first was a maze presenting ten points of choice, each a T-shaped junction and the series so arranged that the order of correct turns formed a double alternation left-left-right-right-etc. This apparatus is spoken of as a spatial maze. The second consisted of a runway following the sides of a rectangle with a cross runway connecting two opposite sides of the rectangle. An animal starting at one end of the cross path and passing through it must return through either the right or the left side of the rectangle. A shutter could be used to close either of the return alleys at its first bend; and a block at the starting end of the cross-path could be shifted to close all three alleys at the junction, or either of the return alleys only. This apparatus is called a temporal maze, a name suggested by the method of operation. The block is set to close all alleys at one end of the cross-path, one return alley is stopped with the shutter, and an animal is placed at the end (next the starting block) of the cross path. When it has entered the open

return alley, the starting block is shifted to close the opposite return alley only. For simple alternation the shutter and block were shifted after the animal had completed his first circuit through the open return and had begun his second through the center path; and such shifts were made after each circuit, thus necessitating circuits alternately through the right and left sides of the rectangle. For double alternation the stops were shifted each time after two circuits had been made through the open side. In either case ten circuits constituted a day's test after which the animal was fed. In the spatial maze, one trip (with ten choices) was given each day with food at the end. The double alternation problem then presented the same order of choices as the spatial maze; but in the one case they were all in different spatial positions, in the other they occurred in temporal succession only (repeating the same spatial location). It may be added that except in one case, the analogous intermediate alleys in the spatial maze were identical as they should be. No rats learned the double alternation, one only learned the simple alternation in the temporal maze, all learned the spatial maze easily. This makes it very probable that the cues used in running the spatial maze cannot be a merely temporal succession of kinaesthetic stimuli; spatial location, in some terms, enters into the successive cues.

Szymanski, in a series of articles (**15, 16, 17, 18, 19, 20**) reported experiments on several animal forms and by various methods. He finds the dog unable to use a stationary visual stimulus as a control to determine discrimination of two compartments; likewise unable to use a moving as over against a stationary visual stimulus. Of two similar platforms on which food was placed, mice learned to avoid the one which gave an electric shock. For some time the association showed more or less frequent failures to work, then rather suddenly became apparently permanent. Fish were able to learn a simple maze with one choice, the stimulus being to get from shallow to deep water. Szymanski decides this is a kinaesthetic-motor association; but the apparatus faced the light in such a way that, so far as the reviewer can see, it might well have been visual control (turning to give light on the right or the left side). The association apparently did not last as long as one day. Frogs were able to learn a sort of one-choice maze.

Many of the experiments used rats in the maze. Szymanski found them to learn equally well during the active and quiet periods of the day cycle; those in the quiet period ran more slowly up to the

thirteenth trial, not thereafter. Rats which were not hungry were allowed to run the maze to enter their cage at the end, but never learned to run without errors; yet this experience in the maze under these conditions enabled them to learn to make perfect runs in a very short time when the need came to get their food in that way. In another experiment the blinds of a maze were stopped and the rats allowed to run the path but without food at the end. They were forced to go forward whenever they were not inclined to do so, but this was not often necessary. Yet after one hundred trips through this path, they did not learn the same maze with blinds open more easily than the control animals. Szymanski assigns as the reason the lack of vital interest such as hunger; but his method does not distinguish between this and objective control (see Carr and Koch above). Some rats which had learned to go through an elevated opening in a puzzle-box, generally used the same type of opening in passing through blocks in a maze.

Arlitt (1) studied the effects of alcohol given in doses of from 1/4 c.c. to 2¼ c.c. in each days feeding and for different periods of time upon the health, fertility and learning ability of white rats and their offspring to the fourth generation. From ten to eighty-two per cent. of the acoholized animals died within six months, while none of the control groups died in the same period. Growth was retarded and this defect was inherited by the offspring. Complete sterility was caused in the males and females by the larger doses, partial sterility by the smaller doses. The drug interfered with the speed but not the accuracy of habits previously formed. The most intelligent animals, measured by the previous learning showed at least as much resistance and length of life as others. Learning ability is decreased, shown especially by decreased speed of running and increased number of trials required in the maze. These defects are transmitted to the second generation and possibly in an even greater degree to the third. They have disappeared by the fourth generation, apparently bred out through sterility.

Buytendijk (4) performed experiments with paramecium in a capillary tube. By moving the tube to keep the animal in a constant part of the field of the microscope, and recording such movements, a record of the animal's changes of position was obtained. He decides that the reversals made at the end of a column of water are not a matter of learning but are due to a flexibility which is at least partly of physico-chemical nature.

Cockroaches, according to the work of Eldering (10) can learn

to go to light rather than darkness, but can learn much more easily to go to the right or left in a double compartment box. When tested with small and large luminous surfaces of the same total luminosity, they showed some preference for the smaller surface. Associations were retained at least a month and were not destroyed by narcosis.

From a series of experiments in which puzzle-boxes are used with dogs, Jong (12) concludes that the dog learns only by trial and error and shows no evidence of reason, knowledge of end, etc. He may see food placed in the accustomed place after he has worked the release mechanism and may uselessly work it again. The fact that an object on which attention is suddenly concentrated acquires significance is not reason, but it is all the indication of reason there is and it is what one has in all trial and error.

Swindle (23) shows that "training which causes an organism to beat with a given bodily member a rythm of a particular numerical value, trains it at the same time to beat with the same member, simultaneously or at different times, other rhythms of the same numerical value," and "all other members are at the same time trained to do numerically the same thing." He explains how the training may be had from the normal life activities of the animal, as in tearing flesh by carnivorous birds, and carried over to other acts, as in cleaning the beak.

Bawden (2) discusses the evolution of behavior, which is supposed to take a large step forward in man because of the substitution of the hand for the muzzle in the manipulation of food with consequent liberation of the mouth and development of speech. The argument then proceeds on the text that "a gesture is an arrested act. A word is a substitute for a gesture. A thought is an incipient word." The discussion of this subject has not evolved much during these many years.

Lashley (13) continues the excellent work in which he and Franz have been engaged on determination of the functions of various parts of the cerebrum in learning, using the rat as subject. In the new work, two types of problem were used for learning. The first was a double platform box in which the animal had to go directly and press a platform on one side of the food box, then pass to and operate one on the other side of the box, then go to the opened door. The platforms were low enough that a rat was not at a disadvantage because of some paresis or weakness. The second problem was one of simple visual discrimination choosing a lighted compartment

rather than a darkened one. Animals with frontal or frontal and parietal lesions were more active than normal. Other operations had little effect on general activity. No disturbance of instinctive reactions resulted in any type of cases. In connection with learning the platform box, the following operations were more or less completely performed: one hemisphere removed, both occipital regions destroyed, both parietal regions, both frontal poles, frontal and parietal of both hemispheres. None of these groups showed loss of ability to learn the platform box compared with normals. Animals with frontal poles removed likewise learned visual discrimination normally. No single part of the cerebrum seems any more important for learning the platform box than any other part. Some part (any part) of the frontal probably functions most normally in this type of habit, but other regions may substitute. The visual discrimination habit, after its formation was not injured by destruction of either frontal or parietal. It was destroyed by occipital operation, but could be re-acquired in normal time. The other acquired acts in the discrimination box were not affected by the lesion, only the specific visual discrimination. The occipital lobes normally function in the visual habit, and probably by direct return motor path to lower centers. Lashley infers that they are not necessary for the visual habit, however. At this point, it seems to the reviewer that considerable portions of this region remained intact, some of which may be necessary. The part destroyed broke the normal connection and other (perhaps neighboring) parts could substitute, but there may be a limit to the portion that can substitute in this specific act, unless indeed, lower centers are doing greater or less part of the substituting in these habits. The point can only be determined by successive operations with learning tests between and covering possibly all of the cortex at once (as the final stage). Paresis seemed to depend upon lesion of both the stimulable cortex and the corpus striatum.

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SPECIAL REVIEWS

The Unity of the Organism. WILLIAM E. RITTER. Boston: Badger, 1919. 2 vols. Pp. xxix + 398, xv + 408.

The present volumes by one of the foremost philosophical biologists deserve careful reading by all students of organic structures and behavior. The author brings to his task a long preparation in zoology and a wide acquaintance with cognate subjects, including speculative philosophy. The discussion throughout concerns the relative merits, explanatory and descriptive, of the organic and the elementistic points of view. Ritter has marshalled an exceedingly wide range of fact and argument in favor of his "organismal" point of view, a standpoint which may be presented by the two following quotations: "*The organism in its totality is as essential to an explanation of its elements as its elements are to an explanation of the organism*" (vol. 1, p. 24). "Obviously, . . . 'the organism as a whole' if taken strictly, could mean nothing less than the organism *and* all of its parts. The whole would not be the whole if some of its parts were omitted; so even from this standpoint one might contend that the 'organism as a whole' must mean the organism taken wholly, that is through and through, no part being neglected, and that consequently instead of connotating the organism analyzed, in reality it connotates just the opposite and thus indicates the only starting point for *complete* analysis of the organism. But 'organismal integrity' not only carries all the other phrase implies so far as mere totality is concerned, but it does more in that *integrity* and its etymological kindred point definitely not only to the parts, but to them as interdependent" (vol. 1, p. 26).

The author considers in much detail the possibility of accounting for biological data in terms of germ layers, cells, protoplasm, and chromosomes, everywhere adducing evidence indicating the significant rôle played by the organism in shaping the final product. Turing from the series of destructive criticisms of the elementist position, the organismal conception is elaborated in terms of the integrations presented by growth, internal secretions, nervous action, and consciousness. The work accomplished by Cannon, Sherrington, and Jennings is utilized extensively, while Loeb's views on

the nervous system and tropisms are vigorously criticized. Psychic integration is indicated most clearly in the Wundtian apperception, which Ritter follows Royce in relating to the tropisms of Loeb. The chief psychologists whose views are utilized are Wundt, James, and Royce.

Ritter's organismal point of view is tremendously important, although, as a psychologist, I believe that other biological fields than psychology are more in danger of the elementist's one-sided views. It is unfortunate that the author chose the chief structural psychologist, Wundt, in order to drive home psychic integration as superior to elementalism, when the functional psychologists have more consistently approached their problem from the organic point of view. (No reference is made to functional and behavioristic psychology.) Yet in spite of the limitations besetting the psychological side of the work, and in spite of the lack of new material in the elucidation of chemical, neural and conscious integration, psychologists will profit by this comprehensive treatment of "the organism as a whole"—and to some it may carry a needed moral.

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Pitch Discrimination in the Dog. G. V. ANREP. *J. of Physiol.*, 1920, **53**, 367–385.

The author, under Pavlov's direction, retested the sensitivity of dogs to tonal stimuli by the conditioned salivary reflex method in order to meet the theoretical and experimental criticisms advanced in 1913 by H. M. Johnson. The latter's work is in turn criticized for utilizing a defective apparatus for the production of pure tone and for including many stimuli other than sound (stimuli from release, from punishment, and from the availability of food with either tone) which would serve to inhibit or obscure the strictly auditory consequences of stimulation. Anrep controlled his work carefully, using mechanical devices for the presentation of food and stimuli, he himself being in another room. A special apparatus for the production of pure tone was constructed based upon the use of a sinusoidal current with a telephone as tone generator.

Discriminations were established in four dogs as follows: 637.5 vibs. from silence; 1,062.5 vibs. from silence; 637.5 vibs. from each of the following: 1,062.5, 850, 722.5, and 680 (one dog only on the last).

Although Anrep observed (through a periscope) gross food-seeking movements to tonal stimuli, the reviewer is inclined as yet to believe that the conditioned reflex method, as applied in Pavlov's laboratory, reveals a sensitivity too slight to condition the rise of gross body habits.

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NOTES AND NEWS

THE following items have been taken from the press:

IN connection with the faculty of medicine of the University of Birmingham a course of ten weekly lectures on the "Principles of Psychotherapy" is to be given by Dr. W. McDougall, F.R.S.

PROFESSOR JAMES R. ANGELL, professor of psychology at the University of Chicago, and chairman of the National Research Council, has been elected president of the Carnegie Corporation.

DR. HARRY WOODBURN CHASE, formerly professor of psychology, was inaugurated president of the University of North Carolina on April 28.

DR. JAMES R. ANGELL has been elected a member of the National Academy of Sciences. The other members of the Academy who represent psychology are: Professors James McKeen Cattell, John Dewey, G. Stanley Hall, and Edward L. Thorndike.

PROFESSOR CHARLES E. SKINNER, head of the department of psychology at Mt. Union College, has accepted a position in the Indiana State Normal School, Indiana, Pa.

DR. CURT ROSENOW, of the Juvenile Psychopathic Institute, Chicago, has been appointed assistant professor of psychology at the University of Kansas.

WITH the completion of the 170th volume of *Pflüger's Archiv.* Max Verworn and B. Schöndorff relinquish the editorship to E. Abderhalden, A. Bethe and R. Höber.